The Unico System®

Equipment Sizing and Duct System Design Guide

INTRODUCTION

This bulletin describes the design steps necessary for a successful Unico System installation. There are only four basic steps. They follow a logical path of reviewing the requirements of the application then choosing the proper equipment with the final result being a detailed duct layout specific to the building.

Every step has a quick method and a more detailed method. Although most applications can be designed without problems using the quick method, it is not unusual to require a more rigorous approach, particularly for complex buildings, or unusual temperature or humidity requirements.

In this bulletin you will notice reference to other bulletins when necessary. For example, refer to bulletin 40-30 to determine the best location of the basic system components. Other bulletins provide detailed specifications and specific installation instructions for each component.

As described above, the steps are as follows:

Step 1. Perform Load Analysis

Step 2. Select Equipment and System Airflow

Step 3. Calculate Required Airflow per Room

Step 4. Create Duct System

STEP 1: Perform Load Analysis.

QUICK METHOD: There is no universal quick method to calculate the heat gain or loss for all climates. Most designers, over a period of time with experience in a specific location, may develop their own quick methods. The most common method is to estimate the load based on the area to be conditioned. This works for many applications, particularly if the homes are similar in construction and size. However, this method can also lead to serious error if the designer does not account for differences, such as insulation values, window sizes, lifestyles, construction quality, shading, etc. Therefore, we always recommend using the detailed method of calculating the load and only use the quick method for estimating a job for quoting purposes.

To assist the designer in estimating the cooling load, Unico has developed the Quik Sizer, Bulletin 40-10. There is no equivalent chart to calculate the heat gain. To calculate the load, simply total the number of outlets and divide by 5 to determine the nominal tonnage (divide number of outlets by 1.4 to determine kW). The room dimensions shown assume the first dimension is an outside wall. For rooms with more than one outside wall, consider the room twice – once for each wall – and then multiply by 0.75.

DETAILED METHOD: The following method is required for all systems.

Design requirements.

- Use ASHRAE/ACCA tables for outdoor design conditions
- summer indoor design temperature should be 2°F (1°C) greater than conventional system indoor design temperature

Table 1. Unico System Cooling Capacity and Condenser Match

Unico System Model	Nominal Condenser Size, tons (kW)	Approx. Rated* Capacity, Btu/hr (kW)	Comparative Capacity**, Btu/hr (kW)	Minimum Airflow, CFM (L/s)	Rated Airflow, CFM (L/s)	Number of Outlets		Maximum Blower Static, in. wc (Pa)
						Min.***	Max.	
1218	1 (3.5)	10,000 (2.9)	10,800 (3.2)	250 (118)	300 (141)	8	15	1.9 (470)
	1.5 (5.3)	15,000 (4.4)	16,000 (4.7)	300 (141)	350 (165)	11	20	1.7 (420)
2430	2 (7.0)	22,000 (6.4)	23,000 (6.7)	400 (188)	500 (235)	13	25	2.0 (500)
	2.5 (8.8)	25,000 (7.3)	27,000 (7.9)	500 (235)	625 (300)	15	30	1.8 (445)
	3 (10.5)	27,000 (7.9)	29,000 (8.5)	600 (282)	700 (330)	18	35	1.6 (400)
3642	3 (10.5)	29,000 (8.5)	32,000 (9.4)	600 (282)	750 (353)	18	35	1.6 (400)
	3.5 (12.3)	37,000 (10.8)	40,000 (11.7)	700 (330)	875 (412)	21	40	2.1 (523)
	4 (14.1)	40,000 (11.7)	43,000 (12.5)	800 (377)	1000 (472)	25	50	1.8 (450)
4860	4 (14.1)	44,000 (12.9)	47,000 (13.8)	800 (377)	1000 (472)	25	50	1.6 (400)
	5 (17.6)	51,000 (14.9)	54,000 (15.8)	1000 (472)	1250 (472)	32	60	1.5 (370)

* Using ARI rated airflow in Table 2. Refer to the ARI Unitary Directory for ratings with specific condensing units.
** Needed capacity of a conventional system to provide the same comfort of the Unico System will vary depending on humidity load.
*** Based on 33 to 40 CFM (15 to 19 L/s) per outlet. Verify minimum total system airflow. Use additional outlets as necessary.

Note — Specifications, Ratings, and Dimenstions are subject to change without notice.

- summer indoor design relative humidity should be 45% rather than 50% as in a conventional system
- Choose appropriate outside design temperature for your specific geographic location.
- Indoor temperature limits:
  refrigerant cooling systems = 70°F (21°C) min.;
  heat pump heating = 90°F (32°C) max.;
  water-based systems = within 10 degrees of water temperature
- Outdoor temperature limits (refrigerant systems):
  cooling = between 75 and 115°F (23 and 46°C);
  heating = between 15 and 65°F (-9 and 18°C)
- Specify to the building owner what design temperatures were used

The first step in designing any heating and cooling system is determining what temperature and humidity the space must be kept at. This must be within the comfort zone of the occupants and within the operating parameters of any special equipment located in the same space. Normally providing human comfort is sufficient for any equipment; therefore, this design guide will only consider human comfort.

The range of temperature and humidity acceptable to most people is described by ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) in their comfort chart. This zone is approximately between 68 and 75°F for heating, between 73 and 80°F for cooling, and between 40 and 60% relative humidity.

The most common design indoor temperature (dry bulb) is

75°F (23.8°C) for cooling, and
70°F (21.1°C) for heating.

These are the default temperatures for all commercially available software programs based on ACCA and ASHRAE design guides. Different temperatures may be selected in these programs, but the user must be careful that the equipment will operate properly at other temperatures.

The default temperatures were chosen as a middle point inside the comfort zone based on relative humidity between 45 and 55 percent (ref. ACCA Bulletin 141). However, the desired indoor temperature depends greatly on humidity, air velocity, activity level, and acclimatization. This is important to remember when designing a Unico System because it removes more moisture and does not create drafts while gently maintaining consistent temperature throughout the room.

Typically, the occupants *lower* the thermostat when using a conventional system to compensate for the lack of humidity removal. This is counter to providing optimum comfort as the home can quickly obtain a "damp cave" or "clammy" feel. The Unico System is just the opposite as it allows the occupants to *raise* the thermostat setting, which provides a "dry cool" feel.

Generally, since the only automatic control is a thermostat, the system only controls temperature. The humidity in the space is not controlled specifically. However, humidity will reach an equilibrium based on the balance between the equipment removal rate and the amount of moisture entering the space.

The Unico System uses significantly less air flow than a conventional system and has thicker heat exchangers. The result is colder/drier air during cooling and warmer air during heating. On average the Unico System will maintain a humidity level 10% lower than a conventional system in the same home (ref. Vineyard, Ed; ASHRAE Transactions; January 2003). This means that the summer indoor design temperature should be 2 to 3°F (1 to 1.5°C) higher when using Unico System compared to the same space when using a conventional system.

To complete the design requirements, choose a representative outdoor temperature. The best source of information is the ASHRAE design temperature tables. These are also located inside the ACCA Manual J. For example, the design temperature for St. Louis, Missouri is 95°F (35°C) for cooling and 2°F (-16.7°C) for heating.

LIMITS Generally, the indoor temperatures are limited only by the type of equipment used and the design of the duct system. The Unico System has two primary types of systems: refrigerant-based and water-based.

Refrigerant based systems will try to maintain a constant capacity. This can cause frosting on the indoor coil if the indoor temperature is too low, especially when the outdoor temperatures are mild. This can begin to occur when the return temperature below 72°F (22.2°C). Therefore, it is good practice to place the return ducts at the warmest point in the room, usually near the ceiling of the top floors. This is also a function of airflow. Maximizing the amount of air will allow colder room temperatures. If the outdoor temperatures are warm, i.e. above 82°F (27.8°C), then frosting will not usually occur until the return temperature is below 70°F (21.1°C) or even 68°F (20°C).

Conversely, for heat pumps, the return temperature is limited to a maximum value to prevent nuisance tripping from the high pressure limit. This occurs when the return air temperature is over 90°F (32°C) when the outdoor temperature is less than 50°F (10°C).

Water based systems have fewer limits. If cooling with chilled water, frosting will never occur because the water temperature does not changed based on load. If heating with hot water, there is no compressor and, therefore, no limits due to pressures. Water-based systems are limited only by the water temperature and the ability of the system to deliver the proper capacity.

A final recommendation is to always inform the building owner what design temperatures were used in the design of the system.

Load Calculations

- Use ACCA Manual J, or ASHRAE method (Wrightsoft Right-Suite for Unico computer program)
- Calculate room-by-room loads for both heating and cooling
- Latent factor (LF) = 1.3 for leaky homes
  LF=1.2 for tight homes
- when installing in an unconditioned space, for cooling systems use 8% duct loss compared to a 18% for a conventional system; for heating systems use 12% duct loss compared to 25% for conventional systems.
- If open staircase between rooms, push 20% of downstairs open room load to the upstairs because of chimney effect, vice versa when heating

Once the design requirements are chosen, a detailed room-by-room heat gain and heat loss must be calculated using generally recognized methods. We recommend either the ACCA *Manual J* or the *ASHRAE Cooling and Heating Load Calculation Manual*. Bulletin 40-50 is for use with the ACCA Manual J Seventh Edition, *Load Calculation for Residential Winter and Summer Air Conditioning*. Refer to Manual J for the heat gain/loss factors. ACCA has a new edition, Edition 8, purported to be more accurate. However, the procedure is more complex and is best suited for use in a computer program. To assist the designer, Unico has partnered with Wrightsoft to provide a specific Small-Duct High-Velocity (SDHV) module with their computer software program. The Right-HV or Right-Suite program is available for purchase directly from Wrightsoft at www.wrightsoft.com.

These calculation procedures are very accurate in calculating the sensible heat load (energy required to change the air temperature) but not so accurate when calculating latent load (energy required to remove moisture during cooling), particularly for older homes that are more leaky. Both sensible and latent load (the sum is called total load) must be considered when selecting the proper equipment. Otherwise, this can lead to serious error when sizing a system, especially when the system must maintain a specific temperature or humidity condition.

The average latent load factor (total load=LF x sensible load) is 1.3 for residential applications (ref. ASHRAE 2001 Fundamentals Handbook, p.28.5) although the value can vary between 1.4 and 1.0. The difference is based on the building envelope tightness, internal moisture sources, and the relative humidity difference between indoor and outdoor. We recommend the following load factors:

LF=1.3 for leaky homes (older homes)
LF=1.2 for tight homes (new construction) and commercial applications
LF=1.1 for computer rooms.

Another feature of the Unico System is that the duct losses are very small. Leakage in a typical system is less than 5% without doing any extraordinary work (reference: Duct Leakage reports from California building inspectors). Typical conventional ducts have 12.7% leakage, sometimes as high as 25% (ref. Cummings, James; Florida Solar Energy Center Report FSEC-CR-397-91). Thermal losses are also very small comparatively because the duct surface area is very small and the insulating values are generally higher. Adding the effect of leakage and thermal losses, the total duct loss for a Unico system are between 8 and 12% compared to duct losses of 18 to 30% for conventional systems.

CHIMNEY EFFECT. Many buildings have rooms or floors that are open to each other. While the load calculations will accurately determine the loads per room for both heating and cooling, there is no way to accurately account for the air movement between rooms or floors with open staircases. This can create a substantial chimney effect in the house, where the warm air from the lower floor rises to the upper floor and, conversely, colder air from upper air falls to the lower floor.

This effect is difficult to predict and both ASHRAE and ACCA are silent on this issue (probably because it is difficult). As in any engineered system, professional judgment and experience must always be used. To assist the designer, Unico recommends that, for cooling, 20 percent of the downstairs load from the rooms connected to the stairwell (do not include distant rooms or closed-off rooms) be shifted to the upstairs. The reverse is true for heating – shift 20 percent from the upstairs to the downstairs.

STEP 2: SELECT EQUIPMENT AND AIRFLOW.

Equipment Selection and Size

- Use ARI ratings to select equipment
- Select basic unit size based on cooling load, do not oversize by more than 1 ton (3.5 kW)
- Choose hot water and electric heater sizes

Selecting the equipment can be difficult when using the published ratings in the ARI Unitary Directory (www.ari.org/primenet) because the directory only publishes the combined or 'total' capacity of the cooling system. Therefore, to assist the designer, Unico publishes the typical 'sensible-to-total' ratio (SHR or S/T ratio) in Bulletin 20-20.2 and 20-20.3 at different entering air temperatures for refrigerant and water based systems, respectively.

The tables and charts in those bulletins should be used for complex control schemes or when the entering air dry bulb and wet bulb temperatures are known. For most systems, the procedure outlined in the next few paragraphs is sufficient.

Under ARI rated conditions of 80°F dry bulb and 67°F wet bulb (26.7°C/19.4°C) the Unico System has a sensible heat ratio (SHR) between 0.58 and 0.65, depending on the condensing unit. Compare this to conventional systems that have a SHR between 0.75 and 0.85.

Because most residential homes have a SHR between 0.70 and 0.80, the conventional systems almost never remove enough moisture whereas the Unico System is more than able to reduce the humidity.

The Comparative Capacity shown in the table is the capacity of a conventional system that equals the comfort of the Unico System. For example, a 2 ton Unico System is rated at about 22,000 BTUH, but it is like having a 23,000 BTUH conventional system because the Unico System removes more humidity.

For dry applications, such as computer rooms, it is necessary to oversize the equipment to provide enough sensible cooling. For proper sizing of the equipment multiply the sensible load by 1.2 to obtain a total and use this to select the equipment.

For heat pump systems, be sure that the system capacity is always greater than the heat loss at all outdoor temperatures. In some cases, supplemental heat may be required, even above that provided by auxiliary electric heat. This can be visualized by creating a heat pump cross plot as shown in Figure 1.

Figure 1 shows how a heat pump alone will be undersized at outside temperatures less than 46°F (point 3). To maintain the space temperature below 46°F at least 5 kW must be added. And below 12°F (point 2) the heat pump must be shut down and 10 kW of electric auxiliary heat must be used. The worst case occurs at temperatures below -5°F (point 1) where the equipment will not maintain the space temperature.

So long as the outdoor design temperature is greater than the point where the equipment is undersized (point 1), the system will be able to maintain the space temperature. If more heat is required do not put in more electric heat than recommended in INST 4894. In the system shown in Figure 1, adding additional electric heat will create very high output temperatures and could short cycle the electric heaters.

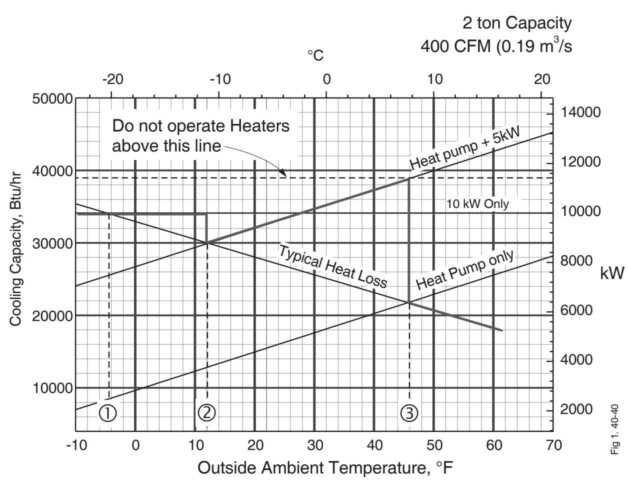

Figure 1. Typical Heat Pump Cross Plot

Unequal Heating and Cooling Loads

If heating is required, verify that the unit heating capacity is sufficient. Do not oversize the cooling system more than one-half nominal ton if the heating capacity is insufficient. If the heating capacity is less than required, you will have to add a separate system for additional heat.

For any refrigerant system use Table 1 to select the unit size based on the cooling capacity. Choose the unit rated capacity that comes closest to the total heat gain. Refer to the ARI Directory for rated capacities of specific condenser-air handler combinations.

For conventional systems if the heat gain (cooling load) falls between two sizes, you would choose the smaller unit for the best overall comfort. This causes the unit to run longer and colder so it can remove more humidity. Humidity removal is not a problem with the *Unico System* so you can select the larger unit to maintain temperature *and* humidity for *all* conditions.

System Airflow

For dry climates, it is important to operate the system with a greater airflow. Refer to **Error! Not a valid bookmark self-reference.** for the proper air flow and unit selection.

Table 2. Minimum Airflow for Refrigerant Coils

Nominal Capacity, Tons (kW)	Unit Size	Airflow, CFM (m3/s)			
		Minimum		ARI Rated	
		Normal	Dry Climate	AC	HP
1 (3.5)	1218	250 (0.12)	300 (0.14)	400 (0.19)	
1 ½ (5.3)		300 (0.17)	350 (0.17)		
2 (7.0)	2430	400 (0.19)	500 (0.24)	600 (0.28)	600 (0.28)
2 ½ (8.8)		500 (0.24)	625 (0.29)		685 (0.32)
3 (11)	3642	600 (0.28)	750 (0.35)	850 (0.40)	
3 ½(12)		700 (0.33)	875 (0.41)	1000 (0.47)	
4 (14)	4860	800 (0.38)	1000 (0.47)	1250 (0.59)	
5 (18)		1000 (0.47)	1250 (0.59)		
Approx. CFM/ton		200	250		

A Note about Heat Pump Efficiency

In the heating mode, the *Unico System* heat pump produces much warmer air temperatures than a conventional system for a better sensation of comfort.

STEP 3: CALCULATE AIRFLOW PER ROOM

In the case where the required number of outlets in a room is different for heating and cooling, a decision must be made whether to adjust the number of outlets by plugging, or to compromise either the heating or cooling in that room. An effort should be made to avoid adjusting the number of outlets by plugging and to take advantage of the air mixing between rooms.

STEP 4: DUCT LAYOUT AND NUMBER OF OUTLETS

This procedure assumes the takeoffs are relatively evenly spaced along the length of the plenum. Small clusters of takeoffs are acceptable. When there is a long length of plenum between clusters or a long distance before the first takeoff, the plenum may have to be oversized or the number of takeoffs may have to be increased.

When the number of heating and cooling outlets for a adjacent rooms differs by less than 10 percent, it makes sense to install the proper number of outlets for the most important season. For example, heating may be more critical in Michigan, so use the correct number of outlets for heating in each room and let the cooling reach its own equilibrium.

Plugging outlets should primarily be used only when the room in question does not communicate with other rooms. Rooms on different floors are one example.

Plenum Design …

Number of Outlets in each room…

a) Cooling or Heat Pump Refer to the ARI Unitary Directory for the rated cooling capacity and record here.

TH1 = ________ rated BTU/Hr (kW)

b) Heating (electric) Refer to Unico instruction INST 4894 for the available size electric duct heaters and compute the capacity here.

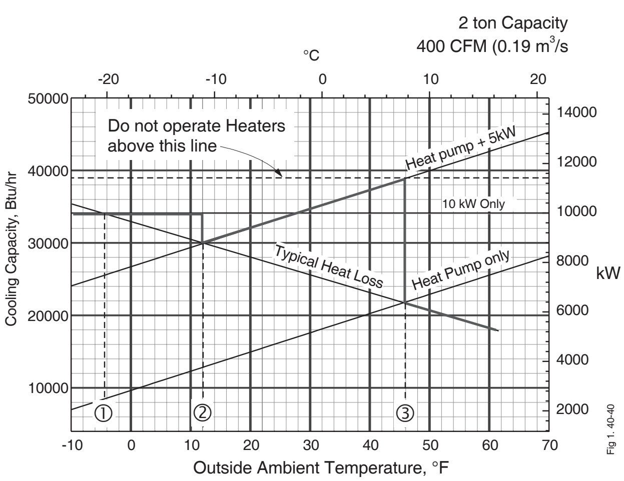

Figure 1. Typical Heat Pump Cross Plot

TH2 = ______kW x 3.413 = _______BTU/Hr

c) Heating (hot water) Refer to Unico Engineering Specification 3994 for the capacity of the hydronic coil at specific water flow rates and temperatures.

TH3 = ________ BTU/Hr (kW)

STEP 3: Determine Required Total Air Flow.

Sum the room-by-room heat gain and heat loss to get the total building load. Calculate the minimum airflow as the larger of the following:

Cooling or Heat Pump From Because most residential homes have a SHR between 0.70 and 0.80, the conventional systems almost never remove enough moisture whereas the Unico System is more than able to reduce the humidity.

The Comparative Capacity shown in the table is the capacity of a conventional system that equals the comfort of the Unico System. For example, a 2 ton Unico System is rated at about 22,000 BTUH, but it is like having a 23,000 BTUH conventional system because the Unico System removes more humidity.

For dry applications, such as computer rooms, it is necessary to oversize the equipment to provide enough sensible cooling. For proper sizing of the equipment multiply the sensible load by 1.2 to obtain a total and use this to select the equipment.

For heat pump systems, be sure that the system capacity is always greater than the heat loss at all outdoor temperatures. In some cases, supplemental heat may be required, even above that provided by auxiliary electric heat. This can be visualized by creating a heat pump cross plot as shown in Figure 1.

Figure 1 shows how a heat pump alone will be undersized at outside temperatures less than 46°F (point 3). To maintain the space temperature below 46°F at least 5 kW must be added. And below 12°F (point 2) the heat pump must be shut down and 10 kW of electric auxiliary heat must be used. The worst case occurs at temperatures below -5°F (point 1) where the equipment will not maintain the space temperature.

So long as the outdoor design temperature is greater than the point where the equipment is undersized (point 1), the system will be able to maintain the space temperature. If more heat is required do not put in more electric heat than recommended in INST 4894. In the system shown in Figure 1, adding additional electric heat will create very high output temperatures and could short cycle the electric heaters.

Unequal Heating and Cooling Loads

If heating is required, verify that the unit heating capacity is sufficient. Do not oversize the cooling system more than one-half nominal ton if the heating capacity is insufficient. If the heating capacity is less than required, you will have to add a separate system for additional heat.

For any refrigerant system use Table 1 to select the unit size based on the cooling capacity. Choose the unit rated capacity that comes closest to the total heat gain. Refer to the ARI Directory for rated capacities of specific condenser-air handler combinations.

For conventional systems if the heat gain (cooling load) falls between two sizes, you would choose the smaller unit for the best overall comfort. This causes the unit to run longer and colder so it can remove more humidity. Humidity removal is not a problem with the *UNICO SYSTEM* so you can select the larger unit to maintain temperature *and* humidity for *all* conditions.

System Airflow

For dry climates, it is important to operate the system with a greater airflow. Refer to **Error! Not a valid bookmark self-reference.** for the proper air flow and unit selection.

a) Table 2, record the minimum required airflow.

Q1 = ________ min. CFM (m^3/s)

b) Heating (electric) Refer to minimum airflow tables in Bulletin 30-34 for required airflow to match the heat loss.

Q2 = ________ min. CFM (m^3/s)

c) Heating (hot water) Refer to performance tables in Bulletin 20-20.4 for required airflow to match the heat loss.

Q3 = ________ min. CFM (m^3/s)

d) Use the largest CFM from steps a), b),and c).

Q = Maximum of **Q1**, **Q2**, **Q3**

STEP 4: (optional) Determine Number of "Full" Outlets

This step is for reference only in order to establish the minimum number of outlets for the job. The total number of outlets for the system must not be less than the minimum shown in Table 1.

Divide the airflow from step 3d by 40 CFM (18.8 m^3/s).

NF = **Q** / 18.8 (**NF** = **Q**/18.8)
= ________ CFM ÷ 40 (= ____ m^3/s ÷ 18.8)
= ________

Where the customer is insistent on absolute quiet, use 33 instead of 40 in above equation.

Note that the "minimum 5 outlets per ton" rule is based on 40 cfm per outlet and 200 cfm per ton. This rule must always be followed for any refrigerant system.

STEP 5: (optional) Determine "Full" Outlet Capacity

This step is for reference only. It gives you a starting point to determine the minimum number of outlets for each room. In many cases, you will use a larger number.

a) Cooling or Heat Pump Divide the capacity of the unit from Step 2a by the number of outlets from Step 4.

C1 = **TH1** / **NF**
= ______ Btu/hr ÷ _____ (= ______ kW / _____)
= ________ Btu/hr/Outlet (kW/Outlet) cooling

b) Heating. Divide the capacity from Step 2b or 2c by the number of outlets from step 4

C2 = **TH2** / **NF** or **TH3** / **NF**
= ______ Btu/hr ÷ _____ (= ______ kW / _____)
= ________ Btu/hr/Outlet (kW/Outlet) heating

STEP 6: Determine the Airflow for each Room

To balance the system properly, determine the air flow required in each room by comparing the room heat gain/loss to the total house heat gain/loss.

a) Cooling or Heat Pump

QR1 = **Q x ROOM HEAT GAIN / TOTAL GAIN**
= ______ CFM x _____ Btu/hr / _____ Btu/hr
= ________ CFM (m^3/s) cooling

b) Heating

QR2 = **Q x ROOM HEAT LOSS / TOTAL LOSS**
= ______ CFM x _____ Btu/hr / _____ Btu/hr
= ________ CFM (m^3/s) cooling

In most cases the required airflow in the rooms will be nearly the same for both heating and cooling applications. If they are significantly different, some sort of balancing must be done for each season.

To accomplish this you will need to install enough outlets for the largest air flow requirement. Then plug the outlets not needed for that particular season. As an option, run additional plenum trunk lines and use automatic dampers capable of shutting the trunk line down. *Under no circumstances should the system be run with less air flow than the minimum required in Step 3.*

STEP 7: Determine the Number of "Full" Outlets in each Room (optional)

Use this step as a reference to compare each room to the typical room (i.e. the Quik-Sizer). If the number is significantly different you should review the heat gain/loss for errors.

a) Cooling or Heat Pump

NF1 = **QR1** / 40
= _______ CFM / (40 CFM/outlet)
= _______ outlets (cooling)

b) Heating

NF2 = **QR2** / 40
= _______ CFM / (40 CFM/outlet)
= _______ outlets (heating)

STEP 8: Determine the Available Static Pressure.

Determine the approximate length of the plenum and branch runs based on the number of outlets per room from Step 7 and the geometry of the building. Refer to Bulletin 40-30 for recommended outlet locations and duct routing methods.

If the distance from the unit to the first outlet is greater than 30 equivalent feet or the distance between outlets is greater than 20 feet, the effect of plenum pressure drop must be considered Table 3 lists the pressure drop for different types of duct for various airflow.

a) Measure the length of the plenum from the unit to the first takeoff (or between takeoffs), adding the equivalent length of any elbows and tees as shown in Table 5.

______ No. Elbows × 15 = _______ ft.
______ No. Tees × 5 = _______ ft.
______ No. Side Branches × 10
= _______ ft.
Straight Length = _______ ft.
EL = _______ ft.

b) Multiply the equivalent length by the appropriate factor from Table 3. This is the plenum static pressure reduction.

SP1 = **EL** × **factor** / 100
= ______ ft × _______ / 100
= _______ inch wc.

c) Subtract SP1 from the maximum blower pressure found in Table 1 to obtain the Available Static Pressure.

SPA = **SP**(max) - **SP1**
= ______ - _______
= _______ inches water (avail)

If the Available Static Pressure is less than 1.5 then do one or both of the following:

1. Increase the plenum size or change to a plenum that gives a lower pressure drop.

2. Design the system for lower plenum static pressure by adding outlets as appropriate. Refer to Figure 2 for airflow at the available static pressure.

STEP 9: Determine Airflow of Each Outlet

To account for the length of the branch runs in each room refer to Figure 2 to find the airflow of each run based on length. Record the cfm per outlet in the form provided in this instruction.

STEP 10: Number of Outlets per Room.

Table 5. Equivalent Length for Fittings

Type of Fitting	Equivalent Length*, ft.
90° Elbow	15
Tee	5
Side Branch	10

* based on 4 feet of straight duct upstream of fitting

Table 3a. Plenum pressure drop, inches of water / 100 ft.

	Inside dimension, inches								
	6½ x 6½, or 7 dia.			8½ x 8½, or 9 dia.			9½ x 9½, or 10 dia.		
CFM	D	RR	M	D	RR	M	D	RR	M
400	0.67	0.82	0.53	0.22	0.22	0.15	0.11	0.13	0.09
500	1.04	1.27	0.80	0.28	0.34	0.23	0.17	0.20	0.14
600	1.48	1.83	1.14	0.40	0.49	0.32	0.24	0.29	0.19
700	2.01	2.48	1.53	0.55	0.67	0.43	0.32	0.39	0.25
800	2.62	3.24	1.97	0.71	0.87	0.55	0.41	0.50	0.33
1000	4.07	5.05	3.04	1.10	1.36	0.84	0.64	0.78	0.50
1250	6.33	7.88	4.68	1.71	2.11	1.29	0.99	1.22	0.76

D = Fiberglass Ductboard, e=0.005 inch (Ref: ACCA Manual D)
RR = Fiberglass Rigid Round, e=0.002 inch (Ref: ACCA Manual D)
M = Galvanized Metal, e=0.0005 inch (Ref: ACCA Manual D)

Table 4b. Plenum pressure drop, Pa / m.

	Inside dimension, mm								
	(165 x 165, or 178 dia.)			(216 x 216, or 228 dia.)			(241 x 241, or 254 dia.)		
L/s	D	RR	M	D	RR	M	D	RR	M
180	5.0	6.1	3.9	1.4	1.6	1.1	0.8	1.0	0.7
230	8.0	9.9	6.3	2.2	2.7	1.8	1.3	1.5	1.1
280	11.8	14.6	9.1	3.2	3.9	2.6	1.9	2.3	1.5
330	16.4	20.2	12.4	4.5	5.5	3.5	2.6	3.1	2.1
380	21.6	26.8	16.3	5.9	7.2	4.6	3.4	4.2	2.7
430	27.6	34.3	20.7	7.5	9.2	5.8	4.3	5.3	3.4
590	51.7	64.3	38.2	14.0	17.3	10.6	8.1	10.0	6.2

D = Fiberglass Ductboard, e=0.051 mm
RR = Fiberglass Rigid Round, e=0.127 mm
M = Galvanized Metal, e=0.0127 mm
248.8 Pa = 1 inch water column; 0.4719 L/s = 1 CFM; 8.16 Pa/m = 1 in.wc/100 ft

Round to the nearest 0.1 outlet; use the greater of the two equations below.

1. Cooling Load (line 13) Divide the room cooling CFM (step 6a) by the outlet CFM (step 9)

NR1	= **QR1** / CFM per outlet from Step 9 = _______ CFM / _______ = _______ outlets (cooling)

. Heating Load (line B.9) Divide the room heating CFM (step 6b) by the outlet CFM (step 9).

NR2	= **QR2** / CFM per outlet from Step 9 = _______ CFM / _______ = _______ outlets (heating)

Use Balancing Orifices.

For small rooms or when only a partial outlet is required, add a balancing orifice at the takeoff connection. Use balancing orifices sparingly to maximize the airflow. Use the following table to determine the best orifice size when the room requires a fractional outlet.

Table 6. Balancing Orifice Combinations

Fraction	Outlet-Orifice Combination
.50	(1) .5
.65	(1) .35
.85	(1) .15
1.15	(1) .5 + (1) .35
1.30	(2) .35

Final CFM Check.

Add the total CFM from each outlet and check that it is equal to or greater than the cfm from Step 3. On system startup, check amperage and voltage for proper airflow.

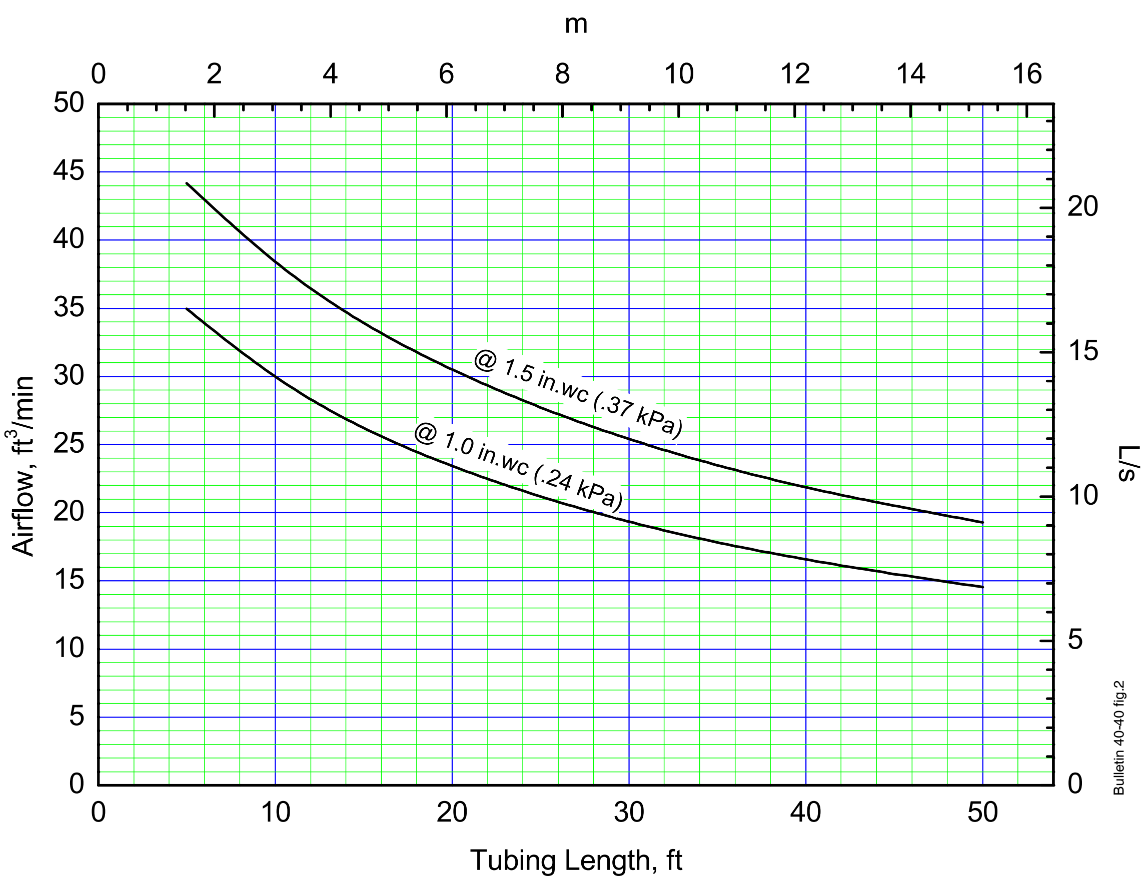

Figure 2. Supply Tubing Airflow Capacity

System Sizing Worksheet

1. Building Load
   - 1a) **T1** = __________ Btuh Heat Gain (cooling load)
   - 1b) **T2** = __________ Btuh Heat Loss (heating load)
2. Equipment Capacity
   - 2a) **TH1** = _________ Btuh Cooling Capacity
   - 2b) **TH2** = _________ Btuh Electric Heat Capacity
   - 2c) **TH3** = _________ Btuh Hot water Capacity
3. Minimum Air Flow, use the largest number
   - 3a) **Q1** = _________ CFM (from Table 2)
   - 3b) **Q2** = _________ CFM (from INST 4894 electric heater instructions)
   - 3c) **Q3** = _________ CFM (from Engineering Spec 3994 for hot water coils)
   - 3d) **Q** = _________ CFM (the maximum of **Q1**, **Q2**, or **Q3**)
4. (Optional) No. of full outlets, **NF** = ________ / **40** = __________
5. (Optional) Capacity of "full" outlet
   - 5a) **C1** = ________ Btuh / ________ = _________ Btuh/outlet (cooling)
   - 5b) **C2** = ________ Btuh / ________ = _________ Btuh/outlet (heating)
6. Required Air Flow per Room
   - 6a) **QR1** = **Q** × **TR1**/**T1** = __________ / ___________
   - 6b) **QR2** = **Q** × **TR2**/**T2** = __________ / ___________
7. (Optional) Number of "Full" outlets per room
   - 7a) **NF1** = **QR1** / **40**
   - 7b) **NF2** = **QR2** / **40**
8. Check Available Static Pressure
   - 8a) Equivalent Length of Plenum before first outlet

______ No. Elbows × 15	= _______	ft.
______ No. Tees × 5	= _______	ft.
______ No. Side Branches × 10	= _______	ft.
Straight Length	= _______	ft.
EL	= _______	ft.

   - 8b) **SP1** = **EL** × **factor** / 100
     = ______ ft × _______ / 100
     = _______ inch wc.
   - 8c) **SPA** = **SPmax** (from Table 1) - **SP1** = ________ - _________ = __________ inches water

   If SPA is less than 1.5 in.wc. (372 Pa), you will not achieve 40 cfm (18.9 L/s) from a typical 10 foot (3 m) branch run. Either continue to step 9 and use more outlets than the minimum, or reduce the number of plenum fittings or use a larger plenum size and repeat step 8, or a combination of both.

9. Determine Airflow from each outlet based on Length, **AR**, (from Figure 2).
10. Determine number of outlets per room
    - 10a) **NR1** = **QR1** / **AR**
    - 10b) **NR2** = **QR2** / **AR**

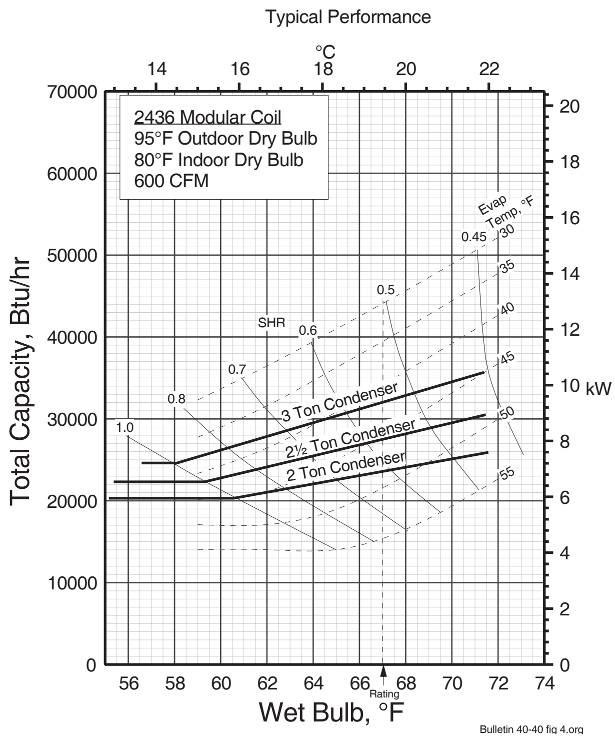

Figure 3. Typical M2430 System Cooling Performance

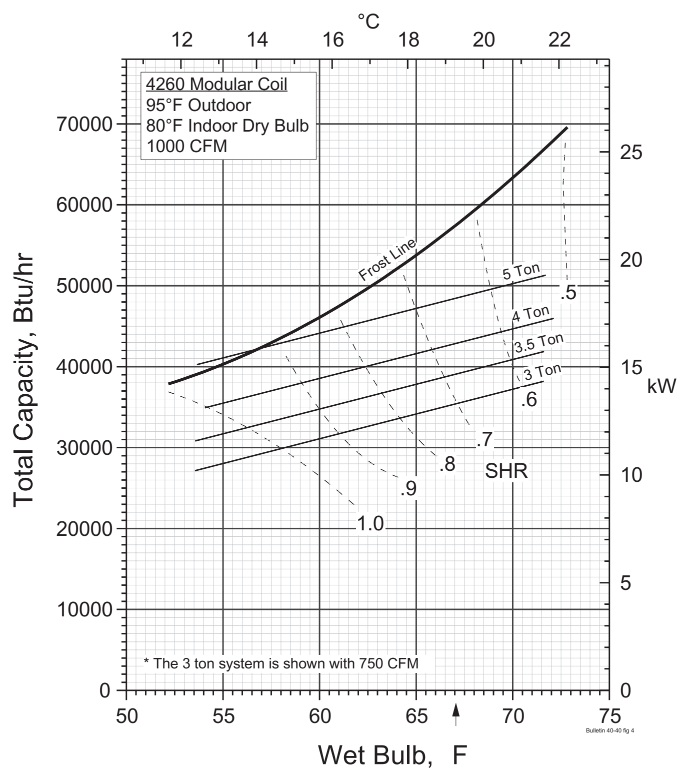

Figure 4. Typical M3642 System Cooling Performance

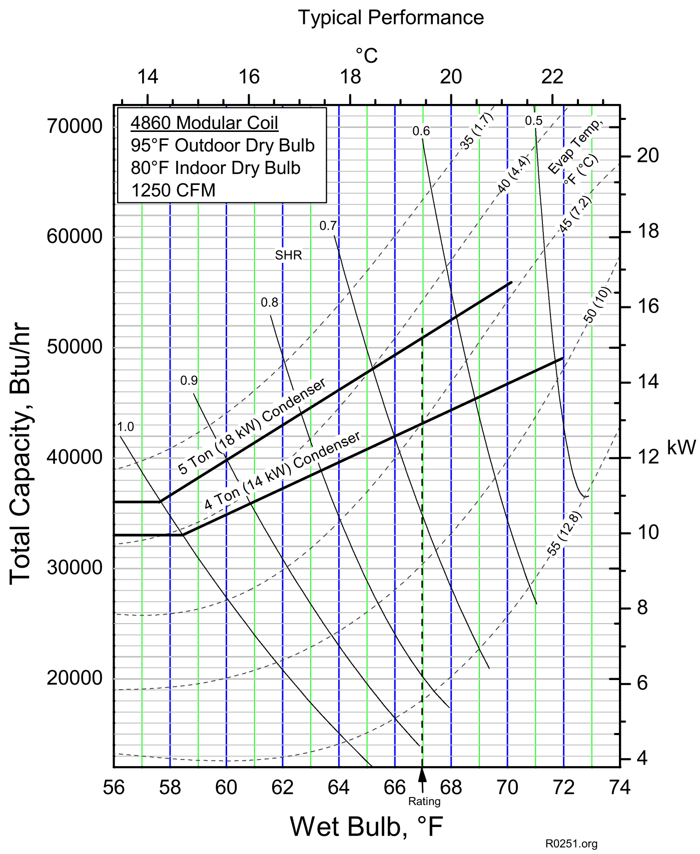

Figure 5. Typical M4860 System Cooling Performance

Room -by-Room Sizing Form

ROOM	REQUIRED BTUH COOLING. TR1	REQUIRED BTUH HEATING TR2	REQUIRED AIRFLOW COOLING QR1	REQUIRED AIRFLOW HEATING QR2	NO. OF FULL OUTLETS COOLING NF1	NO. OF FULL OUTLETS HEATING NF2	RUN NO.	LENGTH RUN L	OUTLET CFM AR	NUMBER OF OUTLETS COOLING NR1	NUMBER OF OUTLETS HEATING NR2
							1				
							2				
							3				
							4				
							5				
							6				
							7				
							8				
							9				
							10				
							11				
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							29				
							30				
TOTALS											

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